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Worker Posture and Fatigue Assessment of Manual Handling Reject Sample in Sample House of Nickel Extraction Process

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Abstract

Background: One of the important nickel extraction processes is mixing nickel ore into Dry Ore Storage (DOS) material as the main intake of Kiln Reduction. To ensure mixed material quality, DOS Sample House operators regularly takes sample and test the homogeneity of samples manually. Material handled by lifting some buckets moved to be mixed, then 1/8 of mixed sample tested and 7/8 disposed. This test activity takes 15 minutes each for 35 samples in one shift. The aim of this study was to evaluate posture, determine the prevalence of work-related musculoskeletal disorder and fatigue of DOS Sample House II workers. **Method:** A random sampling method according to mining work activity type was used to obtain the sample. Total of seven workers data was collected by using Nordic Body Map for symptoms and subjective workload using Rating of Perceived Exertion (RPE) questionnaire; after they finished all tasks of their shift. Four out of 25 tasks in one test were selected (reject sample removal tasks) and assessed using Rapid Entire Body Assessment (REBA). **Results:** The mean age of seven workers was 37,4 years, all men, and they worked for 4,2 years on average. In one sample test, material needed to be lift were average 28,81 kg which above the recommended weight. The highest prevalence of work-related musculoskeletal disorder symptoms were lower back, right forearm, buttock, right shoulder and hip. RPE scored range was 4 to 7 that their work makes them sweat a lot and REBA scored range 8 to 10, which the risk is high, need investigation and immediately implement changes. **Conclusion:** The overall finding indicated that the process of selected tasks, reject sample removal task, will contribute to musculoskeletal disorder either for a short or long time exposure. Future research regarding this section needed to prevent or reduce the occurrence of musculoskeletal disorder.

Keywords: manual handling; mining; posture; REBA; RPE

1. Introduction

There have been nearly 100.000 cases of occupational injury each year reported in Indonesia.(1) This information confirms the 2008 International Labor Organization (ILO) report which Indonesia as the second highest number of work-related accidents of 53 surveyed countries. This showed that number of cases related occupational safety and health (OSH) in Indonesia is quite high; and the actual number is expected to be far higher because mostly underreported. Mining sector has been characterized by most researchers as one hazardous occupation amongst industrial activities.(2)

Mining involves moving materials handled by equipment, mostly large equipment. But some mining activities involve Manual Material Handling (MMH) that can cause of accident, injuries and cumulative trauma disorders.(2) Studies showing positive association of work and physical risk factor for low back disorders were(3): MMH, heavy physical load, whole-body vibration, also frequent bending and twisting. Essentially all MMH tasks in industry is defied lifting, lowering, pushing, pulling, carrying walking, moving excessive load with hands

or body force, or combination of these basic task.[4],[5],[6] These tasks are the most probable factor resulting Work-related Musculoskeletal Disorders (WMSDs) injuries because those tasks have a large degree of freedom and require a stable position.

MMH is an expensive public health problem.[7] The government and industries have to pay for worker's compensation, spend billions on their treatment, also employee insurance claim etc. for musculoskeletal or other injuries. Recognize this issue; a lot of countries have placed some limitation on weight for manual lifting and emphasis administrative and personal intervention to minimize injury risk potentials. A key step in primary prevention of WMSDs is the measurement and evaluation of physical loading on the musculoskeletal system.[8]

One of the important nickel extraction processes is mixing nickel ore into Dry Ore Storage (DOS) material as the main intake of Kiln Reduction. To ensure mixed material quality, DOS Sample House operators regularly takes sample and test the homogenity of samples. However, some parts of the preparation process are handled manually such as lifting, down, pulling and carrying a box containing the sample. The orders of the homogeneity samples test (HST) (Figure 1) are: a) Starting with pick up samples from transporting car; b) Input samples to vibrating screen; c) Measure all sample weight; d) Measure bucket weight of ¾", ¼", ¼" filled; e) Minimize sample size with crusher (repeat 2 times); f) Collect all samples; g) Input to rotating mixer; h) Blend sample for 5 minutes manually; i) Take out sample to splitter and big pan; j) Reject Sample Removal tasks (7/8 of sample); k) Take back big pan and move 1/8 of sample; l) Input to small splitter; m) Take ±500 g to be tested/next process; n) Remove all leftover to reject bucket.

Main objectives of this research were to identify discomfort or WMSDs symptoms of the workers in Sample House using Nordic Body Map[9] as well as to identify their subjective workload using Rating of Perceived Exertion (RPE) questionnaire[10]; and assessed the work posture using Rapid Entire Body Assessment (REBA).[11]

Figure 1. Homogenity Samples Test (HST) in DOS Sample House

2. Method

A random sampling method according to mining work activity type was used to obtain the sample. This study only focused on DOS Sample House II workers. Figure 1 shows the Homogenity Samples Test (HST) on DOS sample house. Total of seven workers data was collected and four out of 25 tasks in one test were selected (reject sample removal tasks) because involve mainly MMH. The main data were obtained through questionnaire distributed to the workers. Respondent voluntarily filled the questions after being briefed about the objectives and item of questionnaire. Observation based assessment conducted by video recording to capture workers activities, also conducting without disrupting the working activity, early detection of WMSDs and able to complete in confined workplace.[6]

The end of research, observation was given on process as whole that affect the worker's activities especially their MMH motions. Reject sample removal task were Unit-Combined MMH task category, means MMH exposure variable within task elements or between task blocks, and it is repeated continuously over task duration.[12]

3. Results and Discussion

3.1 Results

Preparation and sample process were 24 hours work for 7 days in three shift of 8 hours work. There seven workers at DOS Sample House II in one shift: all male, age ranges from 28 to 43 years (mean 37,4 years), and working experience ranges 2 to 14 years (mean 4,2 years).

As seen in Table 1, according to the process flow, buckets of sample material from car moved to the screening machine then mixed in rotating mixer. From 1/8 of mixed sample taken out to be tested and 7/8 portions disposed. This test activity takes 15 minutes each for 35 samples in one shift. At Sample House there were five kind of sample tests need to be done: wet, dry, mining exploration, packaging and driver. But because of work experience and skill each operators was different, some jobs only be processed by few of worker which made an unbalance workload between them.

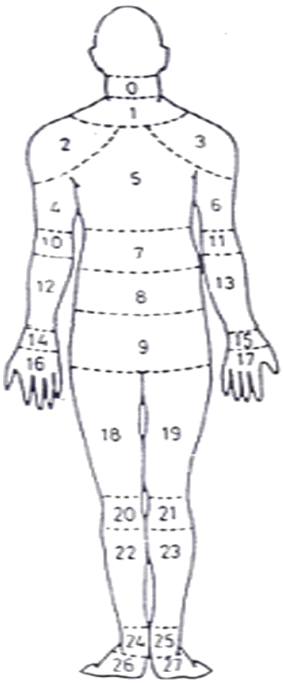
Table 1. Weight Lifting Data of Workers

Opera-tor	Age (years)	Experience (year)	Material handled - lifting, lowering, moving (kg)						
			Sample	Bucket	Total (1)	1/8 = Sample	7/8 = Reject	Big Pan	Total (2)
A	40	14	30.9	0.9	31.8	3.98	27.83	3.6	31.43
B	38	7	19.2	0.9	20.1	2.51	17.59	3.6	21.19
C	28	2	18.5	0.9	19.4	2.43	16.98	3.6	20.58
D	32	2	23	0.9	23.9	2.99	20.91	3.6	24.51
E	43	2	28.1	0.9	29	3.63	25.38	3.6	28.98
F	43	2	33.5	0.9	34.4	4.3	30.1	3.6	33.7
G	38	0.5	42.2	0.9	43.1	5.39	37.71	3.6	41.31

Analysis of Result

Table 2 describes the prevalence of body discomfort by area. Result in this study similar with other research which is the highest prevalence of WMSDs symptoms of workers with MMH task were lower back. It is found that 79% manual handling injuries affect the lower back[13] and 37% of the low back pain worldwide is due to MMH jobs.[14] The other symptoms have high prevalence were right forearm, buttock, right shoulder and hip.

Table 2. Prevalence's of body discomfort

No	Discomfort	Prevalence	Area in picture
0	Rigid Upper Neck	43%	
1	Rigid lower neck	43%	
2	Left shoulder	43%	
3	Right shoulder	57%	
4	Left forearm	14%	
5	Back	43%	
6	Right forearm	71%	
7	Hip	57%	
8	Waist	71%	
9	Buttock	71%	
10	Left elbow	29%	
11	Right elbow	29%	
12	Left arm	29%	
13	Right arm	29%	
14	Left wrist	29%	
15	Right wrist	43%	
16	Left hand	43%	
17	Right hand	29%	
18	Left thigh	43%	
19	Right thigh	14%	
20	Left knee	43%	
21	Right knee	14%	
22	Left leg	0%	
23	Right leg	14%	
24	Left ankle	29%	
25	Right ankle	14%	
26	Left foot	0%	
27	Right foot	14%	

If symptom were separated between left and right part of body (sagittal plane), there more right part of upper body discomfort higher than the left part (shoulder, forearm, and wrist) and left part of lower body were higher (thigh, knee, ankle). This is possibly because the respondent dominant right handed, which when they do MMH tasks they will lift/lower load with right upper limb and supported by left lower limb. Based on use of EMG-assisted biomechanical model, Gallagher and Hamrick conclude that asymmetric lifting increased forces compared symmetric lifting. Furthermore, the demands were shifting to muscles with smaller cross-sectional area, which may be at greater risk of injury.[15]

Table 3. Subjective Workload (RPE)

Perception		Operators						
		A	B	C	D	E	F	G
#10	I think I'm going to pass out							
#9	Maybe I'm going to pass out				▲			
#8	Can keep this phase for a moment							
#7	Sweat too much and I can't talk							▲
#6	Sweat a lot			▲			▲	
#5	Sweat more than usual		▲			▲		
#4	I'm sweating but I'm fine	▲						
#3	Relax but a little hard to breath							
#2	Relax							
#1	Very relax							

RPE mostly scored in range 4-7, indicate that their work makes them sweat a lot. These implying their perception of work were medium to high workload. Fischer[16] stated that psychophysics remains a powerful tool for establishing guidelines to prevent overexertion at work. Also connection between perception of workload and increasing the applied weight[17] would predict that the ratings of perceived exertion and the right part of body discomfort would increase as the tool became heavier. As the tool mass increased, which big pan box weighted 3.6 kg without material filled, larger forces and moments were created and consequently more subjects were identifying discomfort and the RPE increased. Posture assessment focused on four tasks of reject sample removal, as following in Figure. 2, which were: (i) Took out the pan from screening machine, (ii) lift the non-

handled pan, (iii) move and carrying the pan, and (iv) remove the reject samples to reject bucket.

Figure 2. Posture Assessment

Score of REBA assessment on Table 4, mostly in range 8-10, which the risk of WMSDs is high and need investigation to implement changes immediately. Finding in the study agreed with previous studies[18],[19],[20],[21] that MMH mining activities were high risk and process/job redesign is needed.

Table 4. REBA Score

Posture	Operators							Average
	A	B	C	D	E	F	G	
1	7	9	10	6	5	9	9	8
2	9	9	11	10	11	11	11	10
3	9	8	8	11	9	9	9	9
4	9	8	8	8	6	10	6	8

3.2 Discussion

Modern mining is a lot safer than it was in nineteenth century. However the observation provides the clue to very useful connection in much smaller scale, for example many injuries result from poorly-designed tools or equipment or the absence of mechanical aids.[22] Kadikon, et al. reviewed eleven observational methods to assess risk factor in MMH from 1991 until 2015.[6] Result showed that no single tool covers wide range risk factor in assessing MMH, it depend on the limitation of specific work task. It is important to view measurement and evaluation from the perspective of broader efforts to prevent work-related injuries and illness. Because typically the occurrence of discomfort, pain, and/or musculoskeletal disorders prompts an investigation, which is identifying stressful job components as a key so that solution can be developed and implemented.[8]

Rule of MMH[7],[23] every practical has been done to (i) job redesign to eliminate the lifting task altogether, (ii) use a mechanical aid / assistance instead of manual lifting, (iii) auditing/ investigate MMH activities and minimize the forces required, (iv) provision of training that allow lift to be done without twisting and keep the load as close to the body as possible.

Job Redesign

As a part of systematic approach to prevention of WMSDs, measurement and evaluation of physical loading provides valuable information for job design and redesign decisions.[8] Different approach used in evaluation of risk WMSDs, there were psychophysical(24),(16) , calories consumption and heart rate[25],[26] , postural assessment[18],[19],[20] and biomechanical model.[15] This is depend how comprehensive identification, tasks category and research objectives needed as the MMH complexity and variability.

Job redesign to prevent WMSDs is includes modifying the workplace/ workstation layout, because it is crucial consideration. As seen on Figure 3, layout of machine/ equipment at Sample House spread through the workplace, considering similar equipment functionality. Lots of industries used this kind of layout. They usually made the design layout in line with the process workflow. But in this study, workflow of homogeneity test samples

did not in line with layout, which is: 1 - 3 - 4 - 2 - 8 - 9/11 - 8 - 10 - 6 - 7 - 13 - 7 - 5. Thus fact indicated that workers moving and carrying material/samples repeatedly to be processed. Not only layout, according to Table 1, total weight that workers must carry and move was ranged 20.58 to 41.31 kg. This is above standard which 25 kg for male and 15 for female; although it did not exceed an ILO standard which is 24.4 kg per five minutes.

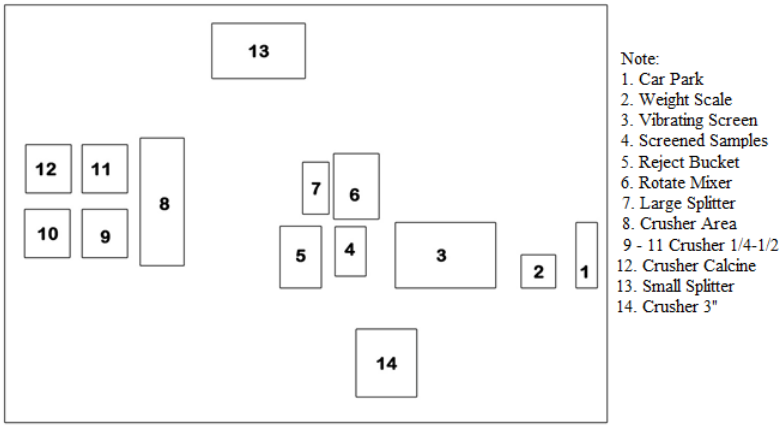


Figure 3. Typical Sample House Layout of Nickel Extraction Process

Lee, et al. study showed that distance significantly affected Maximum Acceptable Weight of Lift (MAWL), with an increase in carrying/moving distance resulting in a decrease in MAWL and also result in an increase in heart rate.[27] Similar result, Sigh, et al. and Asfour, et al. studies concluded that MAWL is affected by lifting in box size, BMI of worker, lifting frequency and vertical distance.[26],[5] This study was conducted to evaluate the response variables on lifting capabilities of workers, based on psychophysical approach. The results show that the MAWL decreased significantly with increase in box size (length and/or width), lifting/lowering frequency, vertical distance and angle of twist of body. But MAWL increase with increase in BMI of worker.[5] Considering MAWL is one of prevention needed to minimize the forces required to MMH tasks. Lin and Cheng[28] found that the interaction of lifting speed and lifting height affected the lifting capacity significantly. The maximal lifting capacity was achieved, also the participants' preferred, around the optimal speed that was neither too fast nor too slow.

Exercise is another preventive measure[29], study conclude that exercise had significant fewer work days lost due to low back disorders then non exercise group. This finding was similar to our result that workers who like sport, example football or volley, and train their body regularly have less discomfort/ WMSDs symptoms. Prevention by mechanical assistance, the example can be applied in a simple thing. Singh, et al. study concludes a box with handle grip make the heart rate does not increases significantly, which mean workload of worker can be minimized by adding handle on the box/big pan.[25] This can be done because less effort is required to lift the box due to suitable and easy grip. Another study concludes[29] that implementation of lift tables and implementation of lift aids resulted respectively 7.42% and over 6.18% reduction in the mean incident rate. Appropriate job design is the most effective solution to MMH problem and has been shown to reduce industrial back injuries by more than 30%.[13]

Provision Training

At Sample House there were five kind of sample tests need to be done, but not all workers can execute them. Work experience and skill each operators was different, this increasing workload on some workers. Moreover, as Table 1 listed the weight of manual handling operator D were 24,51 kg, still on acceptance range, but his RPE on Table 2 indicated high workload (scored 9). After further tracing, operator D's REBA scored higher than the other workers (Table 4); which imply his methods of MMH was not using the right posture. As important as job redesign, soft skill of workers can improve WMSDs prevention more significantly. The prevention of low back injuries in industry can be achieved by careful worker selection, training workers to lift properly, or designing the job to fit the worker.[13],[5]

It is revealed that perception is related to biomechanical demands. Studies involving perception were studied by Muslimah, et al.[24] The study stated even though Lifting Index (LI) criteria more than 1, indicated there is risk of musculoskeletal injury, the task is categorized as light workload. This probably because the worker is used to the task, so the workers energy consumption didn't change much before and after the task. These results imply that workers can get used to the work condition and training will influence workers to positive habit.

Ergonomics is continuous improvement process, good design and strategies intervention should emphasize job demands to the capabilities and limitations of workers. Denny[30] confirm that occupational health interventions in Indonesia resulted in positive impact related OSH. There were significant improvement in knowledge of OSH among workers and health officers, increased awareness of workplace hazards, improve engagement in OSH services, political commitments by local government and improved worker participation in OSH promotion. The capacity of the workforce, engaged to influence work demands on to progress towards healthier, happier, injury-free workplaces.[16]

4. Conclusion

Assessment result shows that workers were exposed with WMSDs risk with medium subjective workload rating and high REBA score; which need for investigation and implementation of changes. The overall finding indicated that the process of selected tasks, reject sample removal task, will contribute to musculoskeletal disorder either for a short or long time exposure. Future research regarding this section MMH task needed to prevent or reduce the occurrence of musculoskeletal disorder, considering discussed variables and biomechanical load.

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